

# **Doctoral Thesis Review Report**

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## **„Statistical Models of Information Processing in Neuronal Systems“**

The submitted thesis is presented as a compendium of five journal articles accompanied by introduction, literature review, results, and conclusion. Each article is briefly commented in a subsection of the chapter 3 Results and full text of the articles is presented in the attachments. The thesis consists of 4 chapters and 5 attachments on 124 pages.

The described research has both theoretical and experimental character. It differs from monographic type of thesis in the structure because the line from theory over experiments to discussion of results is followed in each individual article. However, the conclusion summarizes the results and contribution to the field in detail.

The thesis focuses on the issues of information transmission in neuronal systems. The topic is viewed from the perspective from the rate coding by focusing on the instantaneous firing rate, which integrates rate coding and temporal coding features. The analysis progresses from single neuron to complex neural networks. The findings contribute to enhancing the understanding of the underlying mechanisms of neural coding, offering refined models that better reflect biological reality.

### **Overall evaluation of the thesis**

#### **Relevance of the chosen topic**

The chosen topic of the thesis is up-to-date not only from the scientific and research point of view, but also from the point of view of potential practical impact in biology and medicine. At the same time, it is a very challenging topic. A large part of the research focuses on the creation of statistical models that serve to confirm or refute the formulated hypotheses. The thesis is a contribution to the rate coding, including the variability and randomness of the instantaneous firing rate, saturation of the firing frequency, and related questions.

#### **Aim of the thesis**

The objectives of the dissertation are explicitly stated in the form of hypotheses in each individual article. It was not an easy task for me to orientate in the structure of the thesis. In the standard structure, the objectives are formulated in a separate chapter. Anyway, the objectives are clear and they were met as the Discussion/Conclusion parts of the articles show. The thesis proceeds from the description of the problem area and literature search, through the design of statistical models, their creation, to the testing of the proposed solutions and the discussion of the results obtained. The proposed models were applied to artificial and real data. The author analyzed her results in detail.

#### **The chosen methodology**

The work is methodologically correct. The introduction is followed by chapter 2, which briefly introduces the relevant theoretical parts of firing rate and coding, development of models of neuronal activity, and models of spiking neurons. Chapter 3 is a summary of work presented in articles in the attachments, where also the objectives are briefly mentioned. I consider the attachments II - V to be the key parts, which describe the data studied, the method of investigation, the design of statistical models, and the results along with discussion. The final chapter Conclusion summarizes the results in relation to the presented articles.

## Results of the thesis and its evaluation

The submitted dissertation is well structured, although rather non-traditionally, and has a sound methodological approach. The author guides the solution procedure in both the scientific and experimental parts clearly and correctly. I see the main contribution of the thesis in the proposed, implemented and tested models. The proposed methodology and the methods used were shown to be appropriate.

The work is also of a very good standard in terms of formality.

## Relevance for practice and further development of science

The work is undoubtedly of value to both theoretical and experimental research of information transmission in neuronal systems from the rate coding perspective. It integrates advanced models with empirical studies, while focusing on biophysical properties and adaptation mechanisms. That allows for providing new insights into how neurons encode and adapt to varying inputs. The proposed methodology was validated on experimental data. The contribution of the thesis is evidenced by the published works of the PhD student.

## Comments

I have the following comments on the thesis:

- A separate chapter describing the aim and objectives of the thesis would contribute to better readability of the thesis.
- More detailed conclusion addressing the objectives and their fulfilment and proposing future directions of the research would be welcome.
- I recommend to address these items in the presentation during the thesis defence.

## Questions for discussion

- Can you describe the experimental data used in the article Variability and Randomness of the Instantaneous Firing Rate (attachment II)?
- Can you specify division of work and contribution of each author of the article in attachment III?
- What is the current state of the articles labelled as unpublished in the thesis?
- Is it possible to use the same approach (attachment IV) for data acquired from other species?
- Which approach do you suggest for experimental verification of results reached by computational models?
- What are your recommendations for further development?

## Conclusion

In spite of the above mentioned comments, I can conclude that the submitted thesis testifies to a purposeful and systematic approach of the PhD student to the treatment of the given issue both in terms of scientific approach and experimental results. The PhD student has clearly demonstrated that she has mastered the scientific method and has the necessary depth of theoretical knowledge and experimental experience.

**The thesis fulfils the conditions of an independent creative scientific work, contains original results and thus meets the requirements for the award of the academic degree of PhD. I can thus conclude that I recommend the thesis for defence before the appropriate committee.**



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